

Blood Physiology1

Blood physiology reveals that the blood has a number of functions in the human body. Two key functions are supplying [oxygen](#) and nutrients to tissues, on the one hand, and removing waste products, on the other hand. In addition, blood transports [hormones](#), for example, between organs and tissues. It also assists in transferring heat to the skin and acts as a buffer to protect the body's pH to maintain [homeostasis](#).

The blood makes up about 7% of the weight of a human body, with a volume of about 5.28 quarts (5 liters) in an average adult. Understanding blood physiology depends on understanding the components of blood. The blood is made up of [plasma](#), which accounts for 55% of its volume, and cellular elements that make up the other 45%. These elements include red blood cells, white blood cells, and [platelets](#).

Plasma has four main components. It is 90% water, but it also contains soluble proteins—for example [albumin](#), globulin, and clotting protein, electrolytes, and elements. The albumins, produced by the liver, contribute to colloid osmotic pressure and contribute to the transport of materials such as vitamins, penicillin, fatty acids, and [bilirubin](#). There are three categories of globulins—alpha, beta, and gamma—the latter of which plays a part in the immune system. Plasma as a whole carries [carbon](#) dioxide and oxygen, the respiratory gasses.

Red blood cells, or erythrocytes (RBCs) are the main oxygen transporters and also enable carbon dioxide removal. White blood cells, or [leukocytes](#) (WBCs) are important in allergic reactions, killing parasites, and responding to infection. Platelets, or thrombocytes, are cell fragments, and they are crucial in blood clotting.

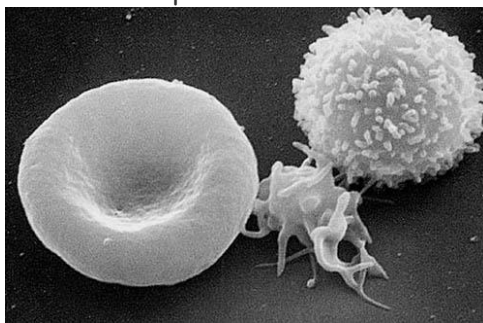
Other important aspects of blood physiology are the ABO blood grouping and the Rhesus factor (RH factor). ABO group and RH factor both refer to antigens that characterize an individual's blood in such a way that it can be determined if transfusion of blood from one individual to another is safe. These are not, however, the only antigens—there are more than 400 distinct blood group antigens.

BLOOD PHYSIOLOGY

I Introduction

A. Composition

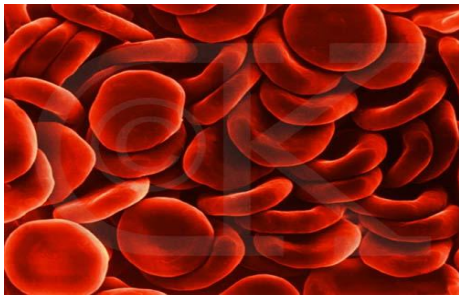
1. formed elements
 - a. erythrocytes (RBC)
 - b. leukocytes (WBC)
 - c. platelets



2. plasma
 - a. fluid: water, ions, hormones

- b. proteins (most made in liver)
 - 1. albumins
 - 2. globulins
 - a. alpha and beta
 - b. gamma
 - 3. fibrinogen
- B. Function to maintain homeostasis
 - 1. transport
 - 2. buffers
 - 3. immunity

II Erythrocytes

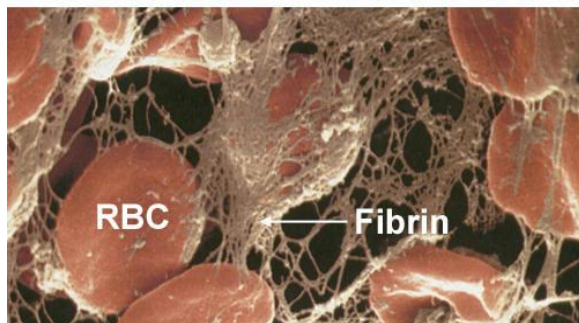


- A. Function
 - 1. gas transport
 - 2. hemoglobin structure
- B. RBC
 - 1. formation from hematocytoblast in red marrow
 - 2. loss of organelles
 - 3. biconcave shape
 - 4. structure and function correlation
- C. Life cycle
 - 1. erythropoiesis
 - a. negative - feedback regulation
 - 1. erythropoietin
 - 2. 120 days ---> destruction
 - 3. recycling
 - a. bilirubin; jaundice
- D. Surface markers (antigens) (blood typing game)
 - 1. ABO group
 - a. type A: A antigens, antibodies to B in plasma
 - b. type B: B antigens, antibodies to A in plasma
 - c. type AB: both A and B antigens, no antibodies in plasma
 - d. type O: no antigens, antibodies to both A and B in plasma
 - 2. agglutination reaction: antibody "clumps" antigens
 - 3. Rh system

- a. Rh+: Rh antigen
- b. Rh- : no Rh- antigen (no antibodies to Rh+ unless exposed to Rh+ antigen)
- c. hemolytic disease of newborn
 - 1. Rh- mom and Rh+ fetus
 - 2. Rhogam

III Platelets

- A. Formation
 - 1. hematocytoblast --> megakaryocyte --> platelets (cell fragments)
- B. Function
 - 1. help in hemostasis
 - a. plug formation
 - b. clot formation
- C. Hemostasis stages (hemostasis animation)
 - 1. vascular spasm
 - 2. platelet plug formation
 - a. collagen exposure
 - b. platelets adhesion
 - c. ADP release; thromboxane release
 - 1. aspirin inhibits at this stage
 - d. platelet accumulation = plug
 - 3. clot formation
 - a. clot definition

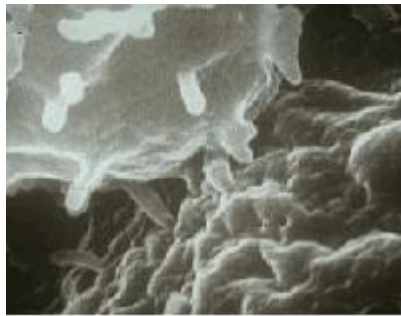


- b. cascade reactions
 - 1. inactive precursors
 - 2. final stages
 - a. prothrombin -----> thrombin
 - 1. heparin effects
 - b. fibrinogen -----> fibrin (clot)

IV Leukocytes

- A. General function
 - 1. mobile defense
 - a. diapedesis
- B. Categories and functions

1. polymorphonuclear granulocytes
 - a. eosinophils
 1. parasites and allergies
 - b. basophils
 1. histamine
 - c. neutrophils
 1. phagocytes
 2. mononuclear agranulocytes
 - a. monocytes
 1. macrophages
 - b. lymphocytes
 3. diagnostic value
- C. Non- Specific Defense
1. all of above except lymphocytes
- D. Specific Defense
1. lymphocytes
 - a. maturation
 - b. types
 1. T-cells



SEM: cytotoxic lymphocyte (top) in the act of recognizing a tumor cell (bottom right).
 Denis M. Callewaert, PhD. Biochemistry, Oakland University

- a. antigen recognition
 - b. types and role
 1. cytotoxic
 2. helper
 3. suppressor
 - c. cell-mediated immunity
2. B-cells
- a. antigen recognition
 - b. antibody production
 1. plasma cells
 - c. humoral immunity

I. **Physiology: Erythropoietin**

- A. Primary hormone regulator of RBC production
- B. **Erythropoietin** sources
 - 1. Fetus: **Monocyte** and **Macrophage** system in liver
 - 2. Postnatal: Peritubular cells in kidney

II. **Physiology: Iron**

- . Total Body Iron
 - 1. Men: 50 mg/kg (or 3.8 grams for 75 kg man)
 - 2. Women: 42 mg/kg (or 2.3 grams for 55 kg woman)
- A. Normal adult iron distribution
 - 1. Functional iron (70%)
 - a. **Hemoglobin** component (80%)
 - b. Myoglobin
 - c. Intracellular respiratory enzymes (cytochromes)

Storage or transport iron (30%)

- . **Ferritin** (primary storage)
 - a. Hemosiderin
 - b. **Transferrin** (iron transport)
- B. Iron Loss

Men and non-menstruating women: 1 mg iron/day

Menstruating women: 1.6 to 2.5% more per day

- . Blood loss varies widely per **Menstrual Cycle**
 - a. Average loss: 10 mg iron/cycle
 - b. Blood loss may approach 42 mg/cycle in heavy flow

Pregnancy: 700 mg iron lost

Whole blood donation (500 cc): 250 mg iron lost

III. **Physiology: Red Blood Cell**

- . **Hemoglobin** produced until amounts to 90% of RBC mass
 - A. **Red Blood Cells** start as **Reticulocytes** in **Bone Marrow**
Reticulocytes are juvenile **Red Blood Cells**
 - . Nucleus extruded once RBC has matured
 - a. **Reticulocytes** contain ribosome remnants
 - i. Immature **Reticulocytes** contain most ribosomes
 - ii. Mature **Reticulocytes** contain least ribosomes

Reticulocytes have 4 day life span

- . **Bone Marrow**: 3 days (less if **Erythropoietin** high)
 - a. Peripheral blood: 1 day
 - B. **Red Blood Cell** survival

Normal RBC: 120 days

Abnormal RBC: May survive as little as 15 days

Following transfusion: RBC survival 2-3 weeks

IV. **Physiology: Hemoglobin**

- . Heme protein complex of 2 pairs of polypeptides
 - A. Six types of normal **Hemoglobin**
Embryonic
Gower I
Gower II
Portland
Fetal **Hemoglobin** (HbF)
- . Primary **Hemoglobin** in fetus

a. Replaced by Adult [Hemoglobin](#) by age 6-12 months
Adult [Hemoglobin](#) (HbA and HbA2)

V. References

- (1998) MMWR Morb Mortal Wkly Rep 47:1

VI. Resources

- MMWR Iron Deficiency Anemia Prevention
<http://www.cdc.gov/mmwr/pdf/rr/rr4703.pdf>

Iron (C0302583)	
Definition (MSH)	A metallic element found in certain minerals, in nearly all soils, and in mineral waters. It has the atomic symbol Fe, atomic number 26, and atomic weight 55.85. It is an essential constituent of hemoglobin, cytochrome, and other components of respiratory enzyme systems. Its chief functions are in the transport of oxygen to tissue (hemoglobin) and in cellular oxidation mechanisms. Depletion of iron stores may result in iron-deficiency anemia. Iron is used to build up the blood in anemia. (From Dorland, 27th ed)
Definition (CSP)	metallic element found in certain minerals, in nearly all soils, and in mineral waters; atomic symbol Fe, atomic number 26, and atomic weight 55.85; it is an essential constituent of hemoglobin, cytochrome, and other components of respiratory enzyme systems; chief function is in the transport of oxygen to tissue (hemoglobin) and in cellular oxidation mechanisms.
Definition (PDQ)	An element with atomic symbol Fe, atomic number 26, and atomic weight 55.85. Check for "http://www.cancer.gov/Search/ClinicalTrialsLink.aspx?id=42183&idtype=1" active clinical trials or "http://www.cancer.gov/Search/ClinicalTrialsLink.aspx?id=42183&idtype=1&closed=1" closed clinical trials using this agent. ("http://nciterms.nci.nih.gov:80/NCIBrowser/ConceptReport.jsp?dictionary=NCI_Thesaurus&code=C598" NCI Thesaurus)
Definition (NCI)	An element with atomic symbol Fe, atomic number 26, and atomic weight 55.85.
Concepts	Pharmacologic Substance (T121) , Biologically Active Substance (T123) , Element, Ion, or Isotope (T196)
MSH	D007501
English	Fe, Fe - Iron, Fe element, ferric ion, Iron, Iron agent, Iron preparation, Iron product
Spanish	agente con hierro, hierro, preparado con hierro, preparado de hierro
Parent Concepts	first transition series (C0682907), Metals, Heavy (C0347988), Transition Elements (C0682906), Metals (C0025552), Trace Elements (C0040577), Iron (C0302583), [TN400] ELECTROLYTES/MINERALS (C0973656), Hematinics (C0018928), Iron AND/OR iron compound (C0303213), trace element supplement (C0556113), Iron Compounds, Unspecified (C0684279), Duplicate concept (C1274013), ELECTROLYTES/MINERALS (C1579396)